

Water Board Training Academy

Introduction to Environmental Economics

Afternoon Session

Cost Benefit Analysis

Cost Benefit Analysis

A policy assessment method that quantifies the value of policy consequences in monetary terms to all members of society.

brings some balance to understanding

Conflicting Goals

Budget Constraints

Imperfect Knowledge

calculates net social benefits (*NSB*) for each policy alternative: net social benefits equal social benefits (*B*) minus social costs (*C*):

$$NSB = B - C$$

Historical Background for CBA in US

1936

The Flood Control Act

1981

Executive Order 12291

Mandated Regulatory Impact Analysis

1994

Executive Order 12866

1995

Unfunded Mandate Reform Act

CBA for projects likely to exceed \$100 Million

Purpose

When markets *fail* and resources are used *inefficiently*, CBA can clarify which of the potential alternative programs, policies or projects (including the status quo) is most efficient.

Types

Ex ante CBA – conducted prior to the intervention.

Ex post CBA – conducted at the end of the intervention.

In medias res CBA- conducted during the intervention.

Project-specific Decision Making

Ex ante analysis is most useful for making resource allocation decisions.

In medias res CBA analysis can also be used for this purpose,
but *ex post* analysis is too late to divert resources to alternative uses.

THE BASIC STEPS OF CBA

CBA can be broken out into nine basic steps:

Step 1 -- Specify the set of alternative projects.

There are usually a huge number of potential alternative projects,

Project versus status quo

All or nothing

With and without

Step 2 -- Decide whose benefits and costs count (standing).

Who counts?

Step 3 -- Catalog the impacts and select measurement indicators.

List the physical impacts as benefits or costs and specify the impacts units.

Impacts include both inputs and outputs.

Impacts may be valued differently by different individuals (i.e., some individuals view the impact as a cost while others view it as a benefit).

Step 4 -- Predict the impacts quantitatively over the life of the project.

Prediction is difficult.

Supply and demand curves usually aren't known; this makes it hard to quantify impacts.

In general, it's more difficult to predict impacts if the project has a long time horizon or if the relationships between variables are complex.

Individuals may exhibit compensating behavior

Third party effects may be hard to measure
spillover effects - externalities

Scientific Knowledge is often uncertain

Step 5 -- Monetize all impacts.

In CBA, value is measured in terms of “willingness to pay”.

Many impacts are difficult to value in dollar terms because they are not traded in markets (i.e. life).

If no individual is willing to pay for an impact, it has a 0 value.

Step 6 -- Discount benefits and costs

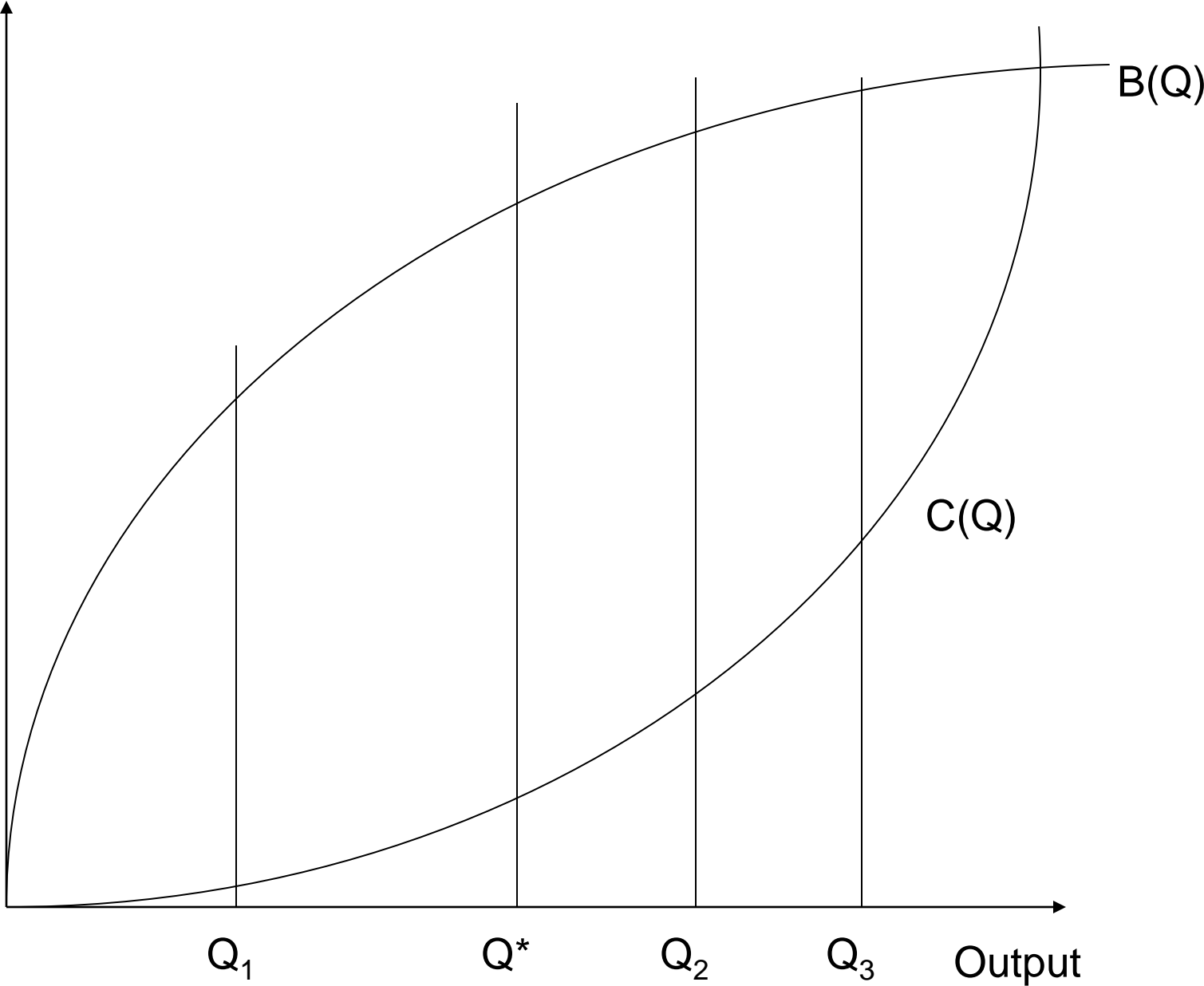
Step 7 -- Compute the net present value of each alternative.

$$NPV = PV(B) - PV(C)$$

Choose the alternative with the largest *NPV*.

The alternative with the largest *NPV* represents the most efficient allocation of resources among alternative.

Benefits(\$)
Costs(\$)



Step 8 -- Perform sensitivity analysis.

There is usually considerable uncertainty about both predicted impacts and their appropriate monetary valuation.

Sensitivity analysis clarifies for decision makers how these uncertainties affect the CBA results.

Just about every variable and assumption can be subject to sensitivity analysis, but time and resource constraints lead analysts to focus on the most important variables or assumptions.

Step 9 -- Make a recommendation.

Net Benefits and Pareto Efficiency

If all benefits are valued using WTP and all inputs are valued using opportunity costs, then the sign of net benefits indicates if it is possible to increase Pareto efficiency.

if net benefits (from trade) are positive, then it is possible to find a set of transfers that makes at least one person better off without making anyone else worse off.

Only implementing Pareto efficient policies is impractical

- information burden of measuring benefits and costs for each individual.

- administrative burden of actually making each required transfer.

- Compensation would induce people to overstate costs and understate benefits.

Benefit

10

Cost

5

Net Benefit

B/C Ratio

Potential Pareto Efficiency (i.e. Kaldor-Hicks criterion)

Alternative decision rule: Adopt only policies that have positive net benefits.

Reasons for adopting it:

It is feasible.

Society maximizes aggregate wealth.

If different policies have different winners and losers, then, in aggregate, costs and benefits may average out over the entire population.

It is possible to do redistribution wholesale rather than within each separate policy.

Application of the Decision Rule in Practice

Adopt all policies that have positive net benefits (if all policies are independent).

If policies interfere or enhance each other, choose the combination of policies that maximizes net benefits.

An Alternative:

Benefit-Cost Ratio = Benefit/Cost

Application of the Decision Rule in Practice

Generally choose the policy with the largest net benefits because the ratio can be manipulated.

Projects may not be independent.
conflicts and synergies

	Costs (\$M)	Benefits (\$M)	Net Benefits (\$M)	Benefit Cost Ratio
Status Quo	0	0	0	-
Project A	2	10	8	5
Project B	10	30	20	3
Project C	3	8	5	2.7
Project D	3	5	2	1.7
Project C and D	6	15	9	1.7
Project E	10	8	-2	0.8

No Constraints?
 Budget Constraint?
 One Project Only
 Max PV(NSB)?
 Max B/C ratio?

Valuation of Benefits and Costs

Measurement of net social benefits and changes in it are relatively straightforward when we know supply and demand curves.

These curves are usually not known but can be estimated for some goods and services that are traded in existing markets.

Not all resource use leaves a behavioral trace.

Valuation of Benefits and Costs

Recall we derive benefits from how we use resources.

Preservation versus Extraction

Active versus passive use

Market value versus existence value

Option value

Bequest value

Distinguishing Between Active and Passive Use

Active use – person makes some rivalrous or nonrivalrous use of the object in question.

We can observe active use because it leaves a behavioral trace.

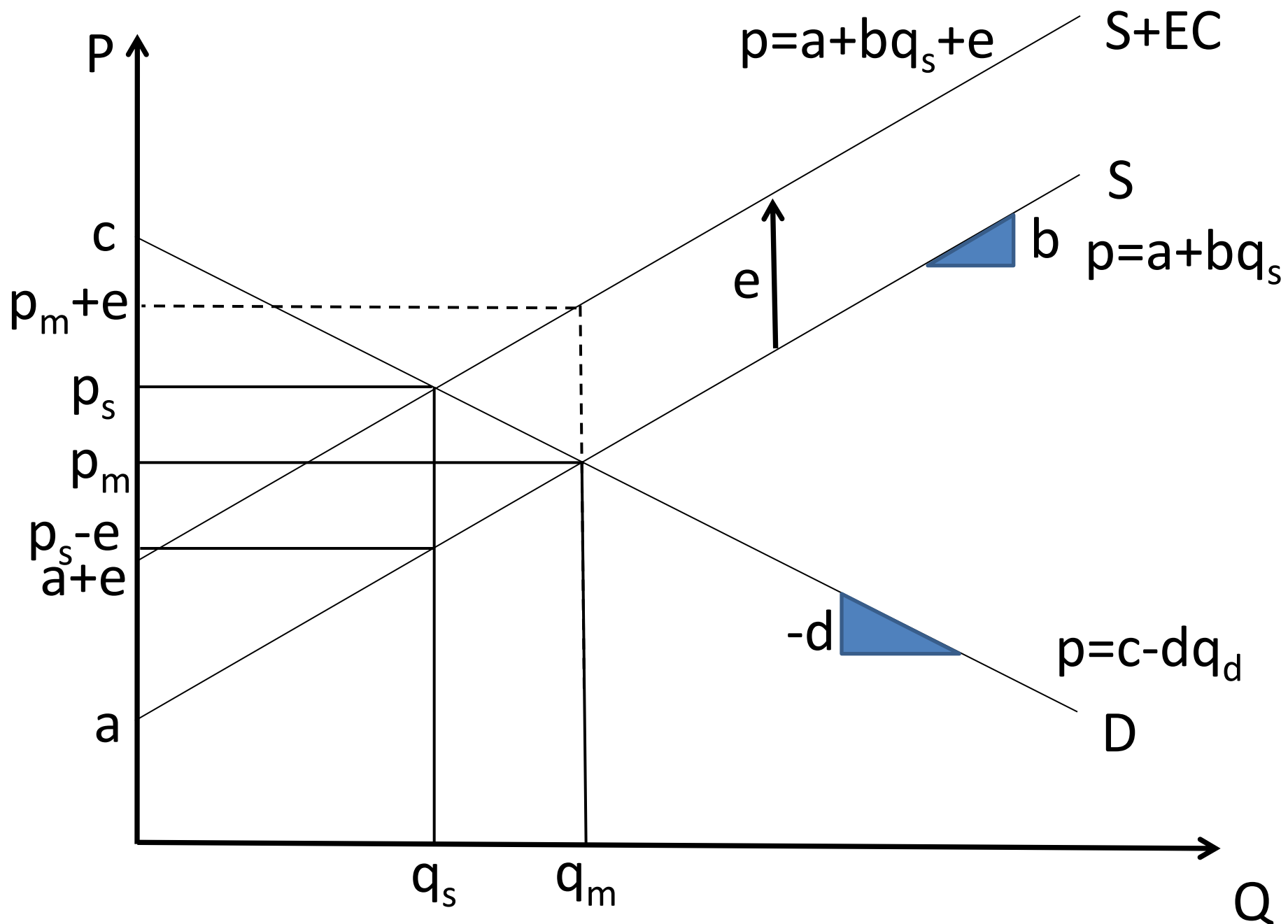
This behavioral trace allows us to estimate demand and supply curves and thus surplus

Passive use or non-use– person values good not actively used.

This is the source of existence value

Specific passive use benefit categories:

- 1. Option value: value to keep open the possibility of use in the future.**
- 2. Pure existence value: good has intrinsic value apart from use value.**
- 3. Altruistic existence value: driven by desire for others to consume the good.**
- 4. Bequest value: altruism is directed toward future generations.**



Consumer Benefits

Markets can provides estimated value from extractive and non-extractive use for some environmental goods and services

lack of information on marginal social cost and markets makes it hard for other environmental goods and services

Examples, value of wild game harvest in US, air quality

In such cases indirect market methods may be useful for measuring value

THE HEDONIC PRICE METHOD

used to value an attribute, or a change in an attribute, whenever its value is capitalized into the price of an asset, such as houses or salaries.

Confidence in results depends on how well individuals know and understand the implications of the attribute that is being valued.

Markets are assumed to adjust immediately to changes in the attributes of interest and to all other factors.

TRAVEL COST METHOD

Mostly used to value recreational sites.

We expect that the quantity of visits demanded *by an individual* depends on

- its price

- the price of substitutes

- income

- tastes

And the costs to travel to and from the site.

Among these travel costs are

- opportunity cost of time spent traveling,

- operating cost of vehicles used to travel,

- cost of accommodations for overnight stays,

- and parking fees at the site.

The sum of all of these costs gives the total cost of a visit to the site.

although admission fees are usually the same for all persons, the total cost faced by each person varies because of differences in the travel cost component.

Consequently, usage also varies, thereby allowing researchers to make inferences about the demand curve for the site

Limitations of the TCM

There is uncertainty about how to value the opportunity cost of travel time or the marginal cost of capital goods used at the site.

People take multiple purpose trips.

People who plan to travel to a site frequently may choose to live near it.

People may value particular features of a site rather than the entire site.

Non-Market Contingent Valuation Techniques

Provides estimated value from use not valued in the market and nonuse value

For some goods, there are no obvious ways to determine preferences through observation of behaviors.

There may be no alternative to asking a sample of people questions about their valuations.

These surveys are called contingent valuation (CV) surveys.

Other approaches may focus on contributions to groups that protect the environment

Examples, land trusts

Relying on contributions to conservation or preservation groups may not accurately reflect WTP.

Existence value or passive use is a pure public good.

likely to misrepresent WTP

Making this more complicated is that those who derive benefits from passive use may also benefit from active use

The primary use of CV is to elicit people's WTP for changes in the quantity of a good.

Valuing "use" or "potential use" goods with CV is relatively non-controversial.

Valuing passive use (nonuse) goods with CV is more controversial.

CV raises problems common to hypothetical scenarios

**understanding,
meaning,
context
familiarity**

This is most severe when the respondent will not consume the good in some way (i.e., passive users).

Applications In Water Quality Control

Nutrient Discharge Standards

NDPES Permits

Animal Feeding Operations

2003 Final

2005 [Waterkeeper Alliance et al. v. EPA](#),

2008 Revised Final Rule

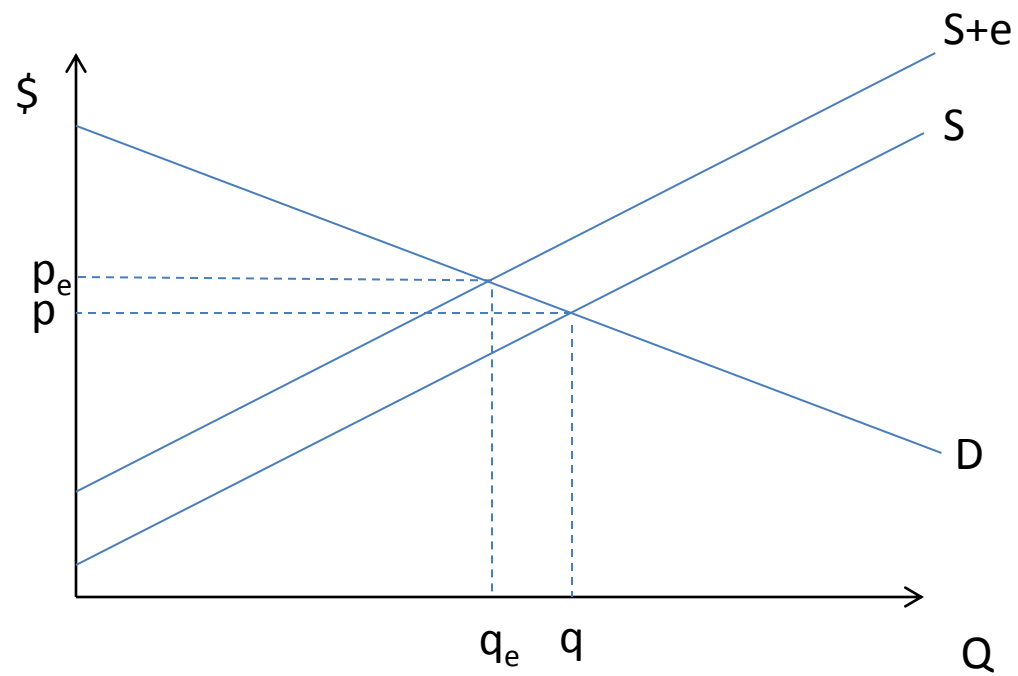
Dischargers and Potential Dischargers must comply
Linked NMPs with NDPES Permits for review

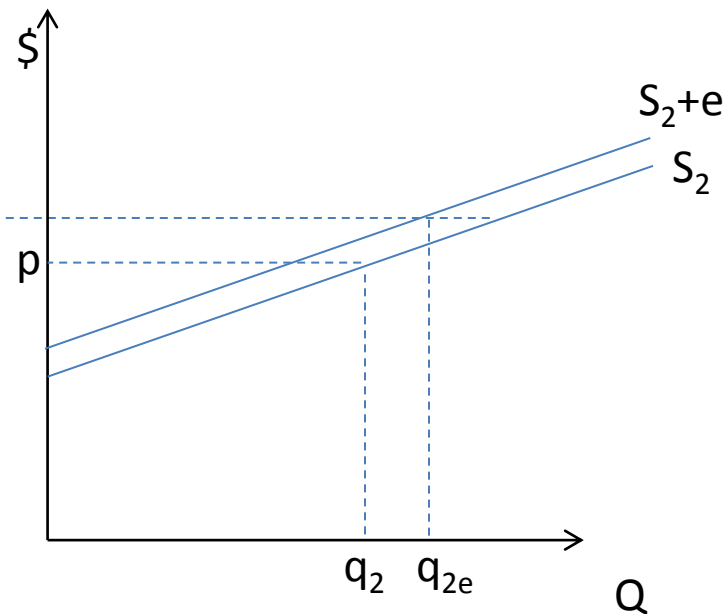
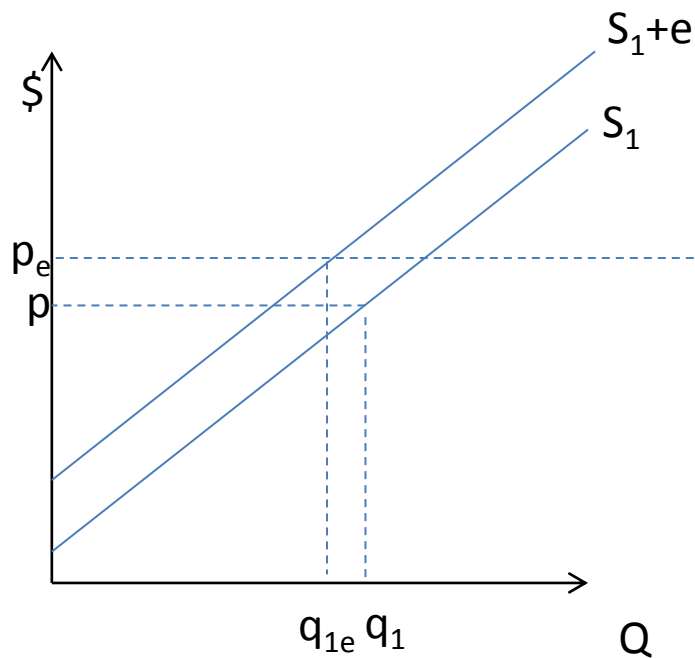
CAF rules

Waste Discharge Requirements (WDR) Order
develop and implement nutrient management plans
submit annual reports

If there are differences in response to the policy then the policy is likely to have distributional effects as well.

As such, we may be interested in knowing the size and distribution of the cost of such a policy.





Why might costs differ?

Different adoption rates among farmers

More available cropland for spreading manure

What if your costs do not change?

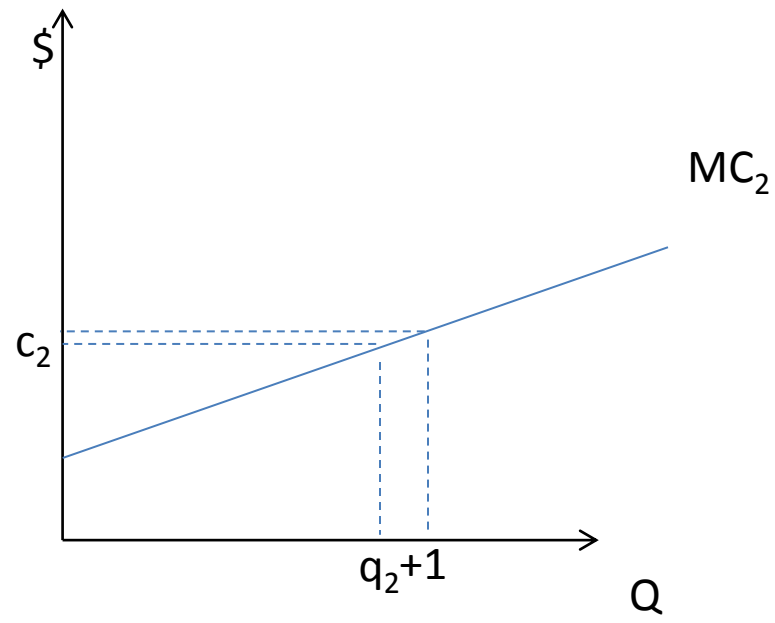
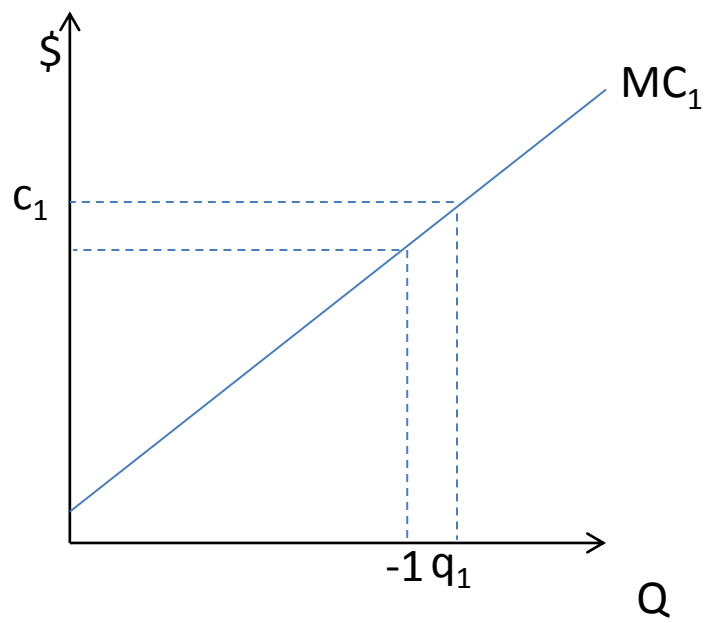
NPS Pollution Control

Hard to monitor
Diverse sources

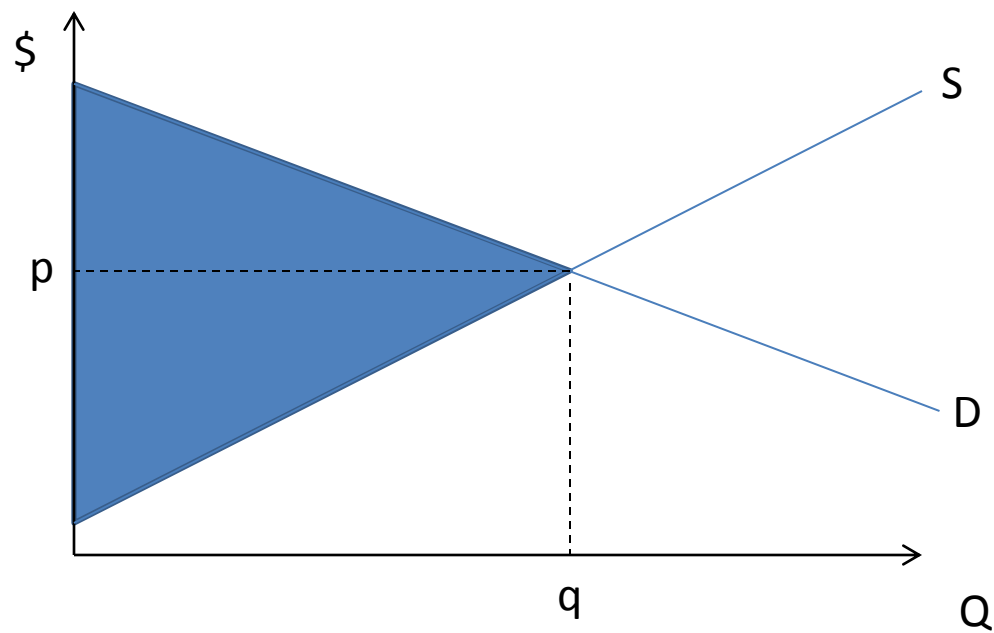
Clean Water Act
Porter-Cologne Act
TMDLs
Allocations

If abatement costs differ there could be potential gains from trading pollution abatement?

As such, we may be interested in knowing the size and distribution of those potential gains from trading.



Market for Pollution Reduction



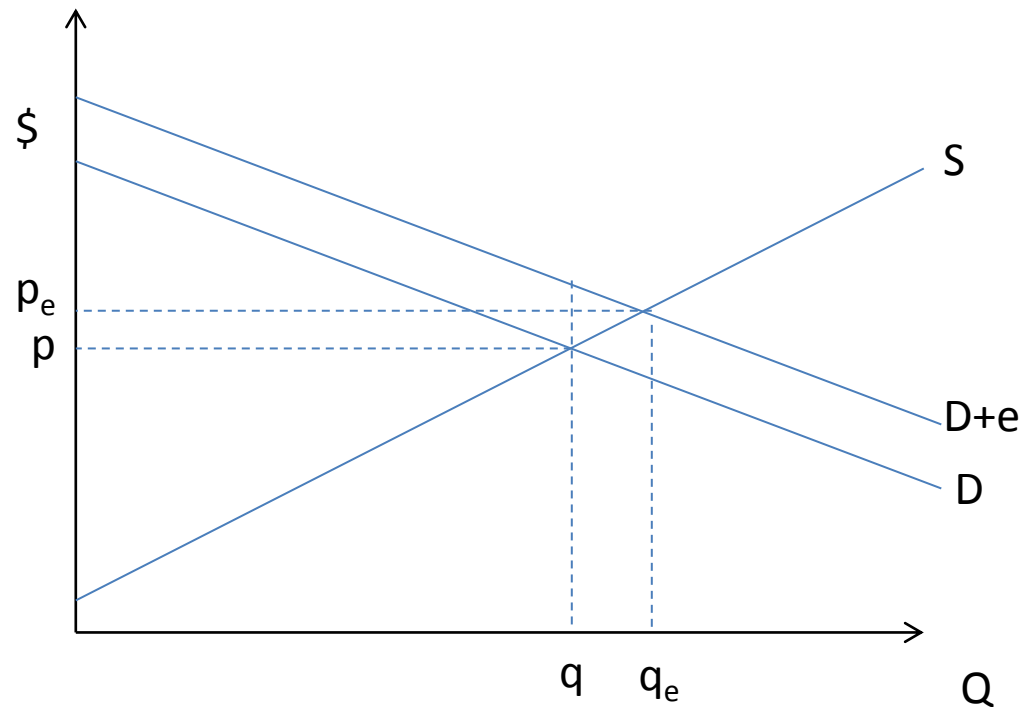
Groundwater Contamination

Brownfields Program

UST Program

-Financing clean-up efforts

Clean groundwater may be seen as a public good since once clean it is clean for all users regardless of how much they pay toward cleaning it up.



Groundwater Contamination

Wellhead Protection – UST Leak Prevention

